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Protecting Electrical Connectors From Corrosion

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Abstract:

This publication describes techniques and apparatuses for protecting electrical connectors from corrosion. An electrical connector may include an electrolytic plating stack-up of layers configured to minimize electrolytic corrosion. The plating stack-ups described in this publication utilize various elements applied in multiple ways to create a cost-efficient and effective solution for minimizing electrolytic corrosion in electrical connectors, thereby improving efficiency and extending the life of electrical connectors.

Keywords:

Electrolytic Plating, Electrical Connector, Receptacle, Universal Serial Bus Type-C (USBc), Electrolytic Corrosion, Plating Stack-Up, Layer, Platinum, Gold, Palladium, Silver, Ruthenium, Rhodium

Background:

Many electronic devices used today contain rechargeable batteries that are rechargeable through a receptacle connector. A mating plug connector connected with a power source (e.g., a charger) can be inserted into the receptacle connector to recharge the battery of the electronic device. A common electrical connector standard utilized today for receptacle connectors and plug connectors is the Universal Serial Bus Type-C (USBc) standard. As configured, USBc connectors contain positive and negative voltage pins that connect the power source to the electronic device and facilitate power transfer. These positive and negative voltage pins, when exposed to an electrolyte solvent (e.g., sweat, saltwater), may begin to corrode due to electrolytic corrosion. Consequently, new electronic device features, such as waterproofing, continue to increase the likelihood of electrical connectors being exposed to electrolyte solvents and thus increase the likelihood of electrolytic corrosion of the electrical connectors. This corrosion can decrease the efficiency of the electrical connectors or render them completely inoperable.

To combat electrolytic corrosion, USBc connectors may be formed using an electrolytic plating stack-up process that produces an anti-electrolytic corrosion layer that contains a noble metal layer on the electrical connector. Common materials utilized for such a noble metal layer include Ruthenium (Ru) and Rhodium (Rh), two rare metals.

Description:

This publication describes techniques and apparatuses for protecting electrical connectors from corrosion. In aspects, an electrical connector includes an electrolytic plating stack-up of layers configured to minimize electrolytic corrosion.

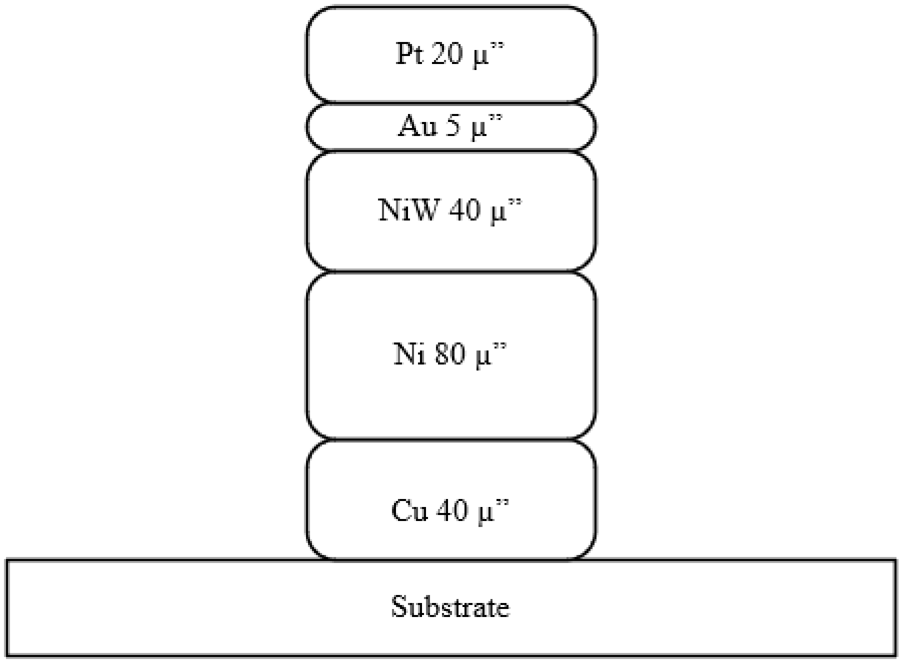

Figure 1

Figure 1 is a schematic illustration of a first electrolytic plating stack-up of layers (the "first stack-up") configured to minimize electrolytic corrosion of electrical connectors. The first stack-up including layers of copper (Cu), nickel (Ni), nickel-wolfram (NiW) (also referred to as nickel-tungsten), gold (Au), and platinum (Pt) sequentially applied to a surface.

The process of forming the first electrolytic plating stack-up of layers on a substrate begins by plating the first layer of copper (Cu) via immersion plating to a depth of 40 microinches (µin). This copper layer acts as a leveling layer to provide a better leveling roughness to the plating stack-up. Then, a nickel (Ni) layer is applied to a depth of 80 µin via immersion plating. A nickel-wolfram (NiW) layer, also referred to as a nickel-tungsten layer, is applied to the nickel layer to a depth of 40 µin. Together, the nickel/nickel-wolfram layers act as a sealing layer due to the low porosity of those elements. An interface layer of gold (Au) is then applied to the nickel-wolfram layer to a depth of five µin via semi-immersion plating. This gold layer acts to minimize the high microcracking risk caused by the consecutive application of high-stress coatings of nickel-wolfram in the previous layer and platinum in the subsequent layer. The last layer in the stack-up is an anti-electrolytic corrosion layer, which uses the noble metal platinum (Pt) to survive electrolytic corrosion. This layer is applied via semi-immersion coating to a depth of 20 µin. Through application of the electrolytic plating stack-up described, the electrolytic plating reaches a total depth of 185 µin.

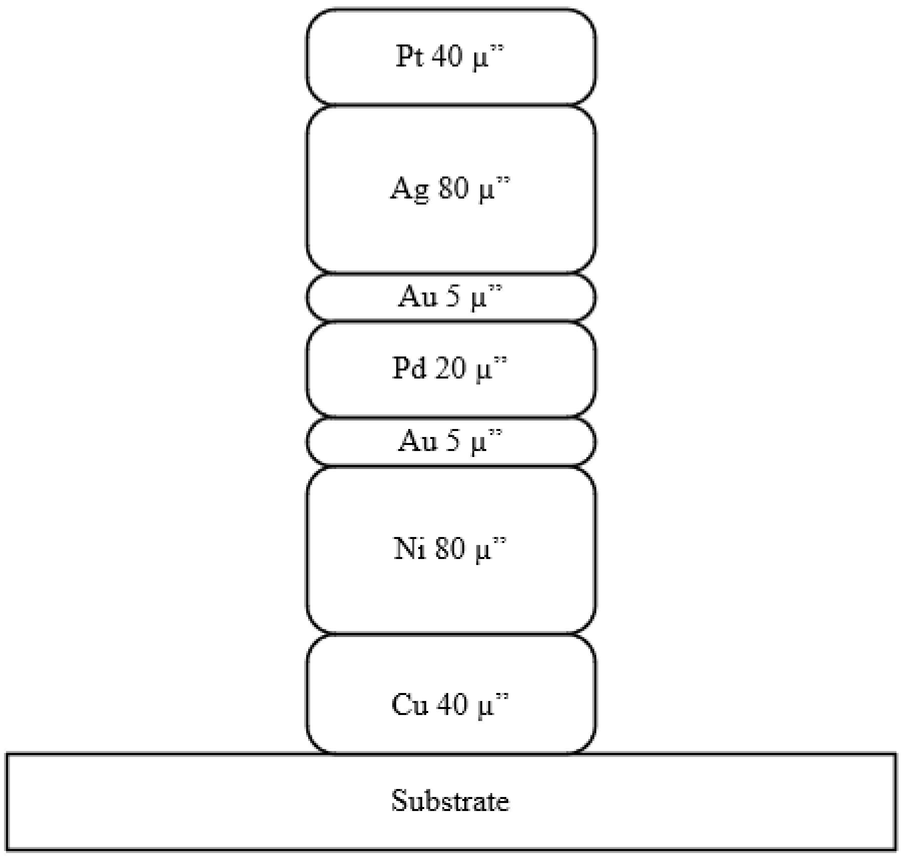

Figure 2

Similarly, Figure 2 illustrates the second configuration, which shares many of the initial layers with the first configuration. The second configuration consists of seven layers applied in the following order: copper (Cu), nickel (Ni), gold (Au), palladium (Pd), gold (Au), silver (Ag), platinum (Pt).

Like in the first configuration, the first layer, consisting of copper (Cu), is applied to the connector to a depth of 40 µin. This layer is referred to as a leveling layer and is similarly used to provide a better leveling roughness to the plating stack-up. The next layer is a sealing layer made up of nickel (Ni) applied via immersion plating. This layer is applied to a depth of 80 µin and provides sealing due to the low porosity of nickel (Ni). Following the sealing layer, the plating stack-up includes five µin of gold (Au) applied via semi-immersion plating. This layer is considered an interface layer and is used to minimize the high microcrack risk caused by the overlapping use of high-stress coatings of nickel (Ni) and palladium (Pd). The following layer consists of palladium (Pd) to a depth of 20 µin. This palladium (Pd) layer is applied via semi-immersion plating and once again is used as a sealant due to low porosity of palladium (Pd). This layer is again followed by another gold (Au) layer plated through semi-immersion to a depth of five µin. This layer similarly acts as an interface layer to minimize microcracking risk caused by the overlapping use of nickel (Ni) and palladium (Pd). This interfacing layer precedes an additional interfacing layer of silver (Ag) applied to a depth of 80 µin through semi-immersion plating. As with the preceding interfacing layers, this layer reduces the risk of microcracking due to the consecutive use of high-stress coatings such as palladium (Pd) and platinum (Pt). Lastly, the plating stack-up utilizes platinum (Pt) to a depth of 40 µin applied through semi-immersion plating. This layer is considered an anti-electrolytic corrosion layer utilizing platinum (Pt) as a noble metal. In combination, the electrolytic plating stack-up is applied to a depth of 270 µin.

In each of the configurations, platinum (Pt) is used as the anti-electrolytic corrosion layer, replacing other higher-priced options such as rhodium (Rh). Additionally, the electrolytic plating stack-up described above employ fewer layers and thinner plating when compared to other possible stack-ups. By replacing these higher-priced options with functioning alternatives and utilizing thinner plating, the electrolytic plating stack-ups provided are both economical and efficient.

Conclusion:

The techniques and apparatuses described herein provide an electrolytic plating stack-up to minimize the electrolytic corrosion of electrical connectors. As such, the techniques and apparatuses described herein can be utilized as an economical and efficient solution to the continued problem of electrolytic corrosion of USBc connectors.

References:

[1] Patent Publication: CN111850642A. Electric connector terminal resistant to anodic electrolytic corrosion and electroplating method of electric connector terminal. Priority Date: July 28, 2020.

[2] Patent Publication: US20180087171A1. Electrical connector electroplating process. Priority Date: September 27, 2016.

[3] Patent Publication: US20200235509A1. Electrical connector, mobile terminal, and electrical connector manufacturing method. Priority Date: September 20, 2017.